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**ADJUSTABLE FLEXURE LOADING
APPARATUS FOR TESTING LONG SPAN BEAMS**

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) PAUL V. CAVALLARO and (2) DANIEL PEREZ, JR., citizens of the United States of America, employees of the United States Government, and residents of (1) Raynham, County of Bristol, Commonwealth of Massachusetts; and (2) Newport, County of Newport, State of Rhode Island, have invented certain new and useful improvements entitled as set forth above of which the following is a specification:

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ADJUSTABLE FLEXURE LOADING

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APPARATUS FOR TESTING LONG SPAN BEAMS

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STATEMENT OF GOVERNMENT INTEREST

7 The invention described herein may be manufactured and
8 used by or for the Government of the United States of America
9 for governmental purposes without the payment of any royalties
10 thereon or therefor.

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BACKGROUND OF THE INVENTION

13 **(1) Field of the Invention**

14 This invention generally relates to an apparatus for
15 flexure testing long, slender shapes.

16 More particularly, the invention relates to an apparatus
17 for flexure testing long, slender shapes such as solid or
18 hollow structural beams, tubes, pipes, cylinders, and the like
19 in which a length of the specimen under test is not limited
20 and the orientation of the specimens is not limited by a
21 position of load columns on a load application device.

22 **(2) Description of the Prior Art**

23 The current art for flexure testing limit the specimen
24 length to an inside distance between load columns of a load
25 application device and require specimens to be oriented within
26 the plane defined by the load columns.

1 The following patents, for example, disclose flexure testing,
2 but do not disclose flexure testing in which a specimen is
3 aligned perpendicularly to the load column plane such that no
4 restriction is imposed on specimen length.

5 Specifically, Glassmeyer (United States Patent No.
6 3,898,873) discloses an intermodel cargo container bottom lift
7 tested by means of a test fixture including adjustable
8 supports which are connected to the lower corner fittings to
9 maintain the container in a raised position free of a
10 supporting surface. The upper corner fittings are first
11 connected to a suitable hoisting device and upon lifting are
12 placed in tension. The lower corner fitting lifting
13 capability of the container is then tested by releasing the
14 tension in the cables, the bottom lift test fixtures being
15 placed in compression.

16 Hayashi (United States Patent No. 4,590,900) discloses a
17 valve supporting arrangement of an internal combustion engine.
18 The upper retainer is for retaining an upper portion of a
19 valve spring shaped like a perforated spinning top and is
20 axially dividable into two identical elements which are
21 coaxially disposed about the upper portion of the valve stem
22 when assuming its operative condition. The retainer has, when
23 assuming the operative position, a configuration which
24 comprises a collar portion which is sized to be coaxially
25 disposed within an upper portion of the valve spring, an
26 annular flange portion extending radially outward from the
27 upper end of the collar portion and engaging with the upper

1 end of the valve spring, and means for achieving a spline
2 connection between the central portion of the retainer and the
3 upper portion of the valve stem.

4 Maciejczak (United States Patent No. 4,789,947)
5 discloses, in conjunction with an unmanned, remotely
6 controllable apparatus for inspecting, testing and viewing and
7 for examination and evaluation of the general condition, state
8 of repair, and of the quality of fabrication of mechanical
9 structures including bridges, an assembly including a guide
10 track carried by a space frame fastened to extend transversely
11 of a bridge or other structure at an underside thereof. The
12 track supports a carrier adapted for transporting, viewing,
13 examining, treating and testing apparatus for controlled
14 movement and manipulation of the apparatus along a path
15 delineated by the guide track. In a preferred embodiment of
16 the invention the carrier supports one or more turntables and
17 one or more articulated arms and linked arm assemblies at
18 remote ends of which selectable viewing and testing devices
19 are attachable. The space frame itself may be moved lineally
20 along the bridge, on an underside thereof so that through the
21 combination of the transversely moving carrier and the
22 lineally movable space frame, an entire aerial zone may be
23 traversed.

24 Strong (United States Patent No. 5,345,826) discloses a
25 static load tester that provides tensile testing of plated
26 test specimens to detect hydrogen embrittlement damage from
27 plating processes. The functional components of the device

1 are centrally aligned within a channel of an I-beam frame. A
2 load cell and electronic readout provide the user with a
3 measure of the tensile force applied to up to eight test
4 specimens mounted end to end in a tester. Tension is applied
5 to the specimens through use of a simple threaded rod and nut
6 load application system at the base of the device. A static
7 load tester may be incorporated into each channel of the I-
8 beam frame, thereby providing a double testing unit.
9 Additionally, a series of I-beam frame tester configurations
10 may be incorporated into one multiple testing unit. Each
11 multiple testing unit has a number of static load testers
12 equal to double the number of I-beam frames mounted into the
13 unit. The tension applied to any individual tester in a
14 multiple testing unit may be displayed on a single electronic
15 readout through use of a switch box coupled between the
16 individual testers and the readout.

17 Diaz et al. (United States Patent No. 5,386,442)
18 discloses an apparatus and a method for measuring and
19 controlling the crack growth rate within a double cantilever
20 beam type test specimen. The arms of the test specimen are
21 fitted with a pressure-actuated bellows to induce a
22 predetermined load and with a sensing assembly to provide
23 feedback on the amount of beam displacement resulting from the
24 application of that load. In this manner, a loaded test
25 specimen may be remotely mounted and adjusted inside the
26 reactor pressure vessel or piping of a nuclear reactor in
27 order to maintain a stress intensity which is constant or

1 which varies in a predetermined manner for inducing stress
2 corrosion cracking or corrosion fatigue in the specimen.

3 Tucchio (United States Patent No. 5,448,918) discloses a
4 biaxial compression testing device formed by two modified
5 beams joined together to form an X-shape with the support
6 structure, such as webs and upper flanges, removed in the
7 region of the X intersection, thereby leaving a rectangular
8 opening. The rectangular opening has dimensions slightly
9 greater than the widths of the beams and is open from the
10 upper surfaces downward to the lower surfaces which are joined
11 together forming an X-configuration. This configuration has a
12 flexing characteristic in the direction perpendicular to the
13 plane of the joined beams. A test specimen support plate is
14 attached to the underside of one of the upper surfaces and is
15 located so as to slide below the opposing upper surface during
16 flexing of the X-beam assembly. Each beam is supported by a
17 roller pin. Additional roller pins are located on the
18 specimen support plate between each beam upper flange and a
19 specimen to be tested. The single actuating force is applied
20 to cause the X-beams to flex into a concave shape thereby
21 applying a part of the actuating force axially along each
22 beam. The configuration provides a force transfer assembly
23 which is actuated by a single load force, but provides a
24 biaxial load to the test specimen.

25 Starostovic, Jr. (United States Patent No. 5,699,274)
26 discloses a performance testing system, i.e., performance of a
27 material under a load concentrated in a single area. The

1 system is computerized and automatically applies a load to a
2 panel to be tested, reads and records deflection of the panel
3 without operator involvement, and provides a printed test
4 report.

5 Simonelli et al. (United States Patent No. 5,913,246)
6 discloses a machine for the cyclic load testing in tension,
7 compression, torsion, shear, or any combination thereof of any
8 one of a number of different sizes, types and configurations
9 of test specimens at a fixed or adjustable predetermined load
10 and cycle rate and comprising a machine frame in which is
11 mounted a drive shaft, any number of intermediate shafts as
12 required, and a camshaft or crankshaft. At the workstation of
13 the machine, appropriate fixtures and tooling are either
14 fixed, rotating, or in motion, as required to conduct the
15 particular test to be performed. When the test specimen is to
16 be in motion, the motion may be derived from a driving source
17 separate from the primary mover or camshaft, for instance, but
18 not limited to an independent motor or cylinder. This source
19 of motion may also be taken through a drive train or any
20 suitable means from the same driving source as the camshaft or
21 from the camshaft itself or from any other moving member in
22 the system. A motion is ultimately imparted to drive the test
23 specimen holder, thereby setting the test specimen in motion.
24 Miller et al. (United States Patent No. 6,042,315)
25 discloses a fastener body comprising a head and a shank
26 fabricated from a composite material. The head has at least
27 one side which extends beyond the side of the shank and has

1 two other sides coplanar with the shank. A fastener for
2 engaging a liner has perpendicular lengthwise and widthwise
3 reference axes and a head and a shank, with the shank
4 extending in a first lengthwise direction away from the head,
5 the head further having at least one extension that extends in
6 the widthwise direction beyond the shank for engaging the
7 liner, wherein substantially all lengthwise directed load
8 components transmitted from the liner to the head are
9 transmitted through the extension.

10 Starostovic (United States patent No. 5,699,274)
11 discloses a performance testing system for woodbased panels.
12 The testing includes performance of a material under a load
13 concentrated in a single area, performance of edge support
14 systems under a concentrated load and performance of a
15 material under static bending conditions. The system is
16 computerized and automatically applies a load to a panel to be
17 tested, reads and records deflection of the panel without
18 operator involvement, and provides a printed test report.

19 Zhou (United States Patent No. 6,216,531) discloses an
20 adapter for use in the testing of shear strength of an
21 adhesive as applied to a test specimen. The adapter has a
22 structure that permits it to be used on testing machines
23 either in a tension or in a compression mode. The adapter as
24 a testing tool includes a pair of coacting force blocks which
25 slidably engage each other and move relative to each other.
26 Each such force block has a central opening into which a test
27 specimen may be inserted. The openings in each of the force

1 blocks engage a different one of the two test coupons that
2 make up a testing specimen. The force blocks further have
3 bearing surfaces that oppose each other so that they may
4 engage the like opposing ends of the test specimen.

5 It should be understood that the present invention would
6 in fact enhance the functionality of the above patents by
7 providing an adjustable apparatus for supporting long span
8 beams in a flexure testing machine regardless of their length
9 or orientation.

10

11 SUMMARY OF THE INVENTION

12 Accordingly, it is a general purpose and primary object
13 of this invention to provide an adjustable apparatus for
14 supporting long span beams.

15 It is a further object of this invention to provide an
16 adjustable apparatus for supporting long span beams in a
17 flexure testing machine.

18 It is a still further object of this invention to provide
19 an adjustable apparatus for supporting a long span beam
20 specimen in an orientation normal to that of the operating
21 structure on a load application device.

22 It is a still further object of the invention to provide
23 an adjustable apparatus for supporting a long span beam
24 specimen that is simple to operate and easily implemented into
25 existing load testing devices.

26 To obtain the objects described, there is disclosed an
27 adjustable apparatus for supporting a long span beam specimen

1 in a flexure test by a load application device. The apparatus
2 includes an upper support structure including an elongated
3 support beam, at least one support bracket adjustably
4 mountable along a longitudinal span thereof, and a saddle
5 member selectively pivotally mounted in the at least one upper
6 support bracket for engaging with a specimen under test. The
7 upper support structure is positioned normal to the load
8 application device and a lower support structure is positioned
9 parallel and co-planar to the upper support structure. The
10 lower support structure includes an elongated support beam, at
11 least one spacing member adjustably mounted along a
12 longitudinal span thereof, a lower support bracket adjustably
13 mounted along a longitudinal span of the spacing member, and a
14 saddle member selectively pivotally mounted in the lower
15 support bracket for engaging with a specimen under test.

16

17 **BRIEF DESCRIPTION OF THE DRAWINGS**

18 The appended claims particularly point out and distinctly
19 claim the subject matter of this invention. The various
20 objects, advantages and novel features of this invention will
21 be more fully apparent from a reading of the following
22 detailed description in conjunction with the accompanying
23 drawings in which like reference numerals refer to like parts,
24 and in which:

25 FIG. 1 is a perspective view of a specimen supporting
26 apparatus in a characteristic flexure testing environment
27 according to a preferred embodiment of the present invention;

1 FIG. 2 is an exploded bottom perspective view of a top
2 fixture of the specimen supporting apparatus shown in FIG. 1;
3 and

4 FIG. 3 is an exploded top perspective view of a bottom
5 fixture of the specimen supporting apparatus shown in FIG. 1.

6
7 **DESCRIPTION OF THE PREFERRED EMBODIMENT**

8 In general, the present invention is directed to a
9 specimen supporting apparatus generally intended for use in
10 flexure testing of long slender shapes (such as, but not
11 limited to, solid or hollow structural beams, tubes, pipes,
12 cylinders, and the like) in which the load-deflection or
13 stress-strain characteristics of a specimen being tested are
14 sought.

15 Referring first to FIG. 1, there is shown a perspective
16 view of a specimen supporting apparatus 10 according to the
17 present invention and in a working environment of a typical
18 flexure testing device.

19 The specimen supporting apparatus 10 includes an upper
20 support structure 11 and a lower support structure 12. These
21 upper and lower support structures, 11, 12, are each formed in
22 a basic I-beam shape. For the purposes of the present design
23 shown, these upper 11 and lower 12 support structures are
24 formed of aluminum 6061-T6 W6x25 I-beams, however, other
25 materials known to those skilled in the art may be used.

26 Referring still to FIG. 1, it can be seen that the upper
27 and lower support structures 11, 12 are positioned parallel to

1 and co-planar with each other. The upper support structure 11
2 is shown mounted transverse to a moving upper platen 100 of
3 the testing device and the lower support structure 12 is shown
4 mounted transverse to a lower stationary platen 102 of the
5 testing device. The upper platen 100 is spaced from the lower
6 platen 102 by a pair of hydraulically operated columns 104 as
7 is known in the art such that the upper platen 100 is
8 adjustably positioned with a testing force relative to the
9 lower platen 102. Operation of the testing device is omitted
10 for the sake of brevity and as having no part of the subject
11 invention other than explanation of a suggested environmental
12 use of the specimen supporting apparatus 10 being described.

13 Additional details of the upper support structure 11 and
14 the lower support structure 12 of the specimen support device
15 10 are shown in each of FIGS. 2 and 3, respectively and are
16 intended to be referenced in connection with FIG. 1 and the
17 following description.

18 The upper support structure 11 is shown in FIG. 2 in an
19 inverted and exploded perspective view in order to better
20 understand the parts thereof. Specifically, the upper support
21 structure 11 is shown in an I-beam shape with opposing end
22 plates 14, 16 and an inner wall 18 perpendicular to and
23 spacing apart the end plates 14, 16, thus defining the "I"
24 shape of the structure. A plurality of paired and spaced
25 apertures 44 are formed through one of the end plates 16 along
26 an entire length thereof.

1 At least one support bracket 20 is mounted to the
2 apertured end plate 16. The support bracket 20 includes a
3 base portion 22 for surface contact with the apertured end
4 plate 16 and side walls 24 projecting from opposing sides of
5 the base portion 22 and away from the fixture 10. The base
6 portion 22 of the support bracket 20 has apertures 26 formed
7 therein which are aligned to mate with corresponding apertures
8 44 formed in the end plate 16 of the upper support structure
9 11. The connection of the support bracket 20 to the end plate
10 16 is with suitable fixing means such as screws, bolts, or the
11 like.

12 Each of the projecting side walls 24 of the support
13 bracket 20 include a centered slot 28 at the distal end
14 thereof and a pair of apertures 30, one to each side of the
15 centered slot 28. A saddle member 32 includes a saddle
16 portion 34 and opposing pins 36 extending from outer ends of
17 the saddle portion 34 such that the pins 36 seat into the
18 centered slots 28 of the support bracket 20 with the saddle
19 portion 34 fit between the side walls 24 and enabling pivotal
20 rotation of the saddle member 32 with respect to the support
21 bracket 20. Each pin 36 is secured in the centered slots 28
22 with a slotted fixing plate 38. The slotted fixing plate 38
23 is rectangular and includes a slot 40 formed in an edge
24 thereof with an aperture 42 on each side of the slot 40. The
25 slot 40 slides over the pin 36 of the saddle member 32 and the
26 apertures 42 align with the apertures 30 of the side walls 24
27 for securement by any suitable means such as a screw, welding

1 or the like. This securement enables movement of the saddle
2 member 32 without separation from the support bracket 20.

3 Still referring to the upper support structure 11, if a
4 single support bracket 20 is utilized, then it is positioned
5 at the mid span of the upper support structure 11. This
6 arrangement enables a three-point flexure loading in
7 connection with the lower support structure 12.

8 If two support brackets 20 are utilized, then each
9 support bracket 20 is equidistantly positioned to each other
10 from a mid-point of the upper support structure 11 according
11 to the matching paired aperture patterns 44 between the upper
12 support structure 11 and the support brackets 20. This
13 arrangement enables a four-point flexure loading in connection
14 with the lower support structure 12. The upper support
15 bracket 20, in whatever number utilized, is attached to the
16 apertured end plate 16 of the upper support structure 11 with
17 bolts or other suitable fastening means (not specifically
18 shown for simplicity). It should be understood, however, that
19 these support brackets 20 are movable along the length of the
20 upper support structure 11 and should therefore be fixed with
21 secure, yet removable means.

22 Referring now to details of the lower support structure
23 12, the lower support structure 12 is also shown in an I-beam
24 shape with opposing end plates 50, 52 and an inner wall 54
25 perpendicular to and spacing apart the end plates 50, 52, thus
26 defining the "I" shape of the structure. A plurality of
27 paired and spaced apertures 46 are formed through one of the

1 end plates 52 along an entire length thereof. These paired
2 and spaced apertures 46 are in the end plate 52 which faces
3 the similarly formed apertures 44 of the upper support
4 structure 11.

5 At least one offset member 56 is provided in connection
6 with the lower support structure 12. This offset member 56 is
7 bolted to the lower support structure 12 using a paired
8 aperture pattern 58 that matches the spacing of the paired
9 apertures 46 in the end plate 52 of the lower structure 12.
10 The offset member 56 provides an offset clearance between a
11 specimen under test and the lower support structure 12 such
12 that the specimen under flexure loads will not deflect to the
13 point where contact between the specimen and lower support
14 structure 12 is made.

15 The offset member 56 is structurally similar in shape to
16 the lower support structure 12 in that it is of an I-beam
17 shape. The I-beam shape of the offset member 56 includes
18 opposing end plates 60, 62, each having paired aperture
19 patterns 58, and an inner wall 64 perpendicular to and spacing
20 apart the end plates 60, 62. The offset member 56 is
21 substantially shorter than the lower support structure 12,
22 spanning only approximately three sets of paired apertures 46
23 thereon.

24 A slider 66 is adjustably positioned with respect to the
25 offset member 56. The slider 66 includes a support leg 68
26 with a T-shaped base 70 and a support bracket 72 at an end
27 opposing the T-shaped base 70. The support bracket 72

1 includes a base portion 72a integrally connected to the
2 support leg 68 and side walls 72b projecting from opposing
3 sides of the base portion 72a and away from the offset member
4 56.

5 Each of the projecting side walls 72b of the support
6 bracket 72 include a centered slot 74 at the distal end
7 thereof. A saddle member 76 is seated in the support bracket
8 72 and includes a saddle portion 78 and opposing pins 80
9 extending from outer ends of the saddle portion 78 such that
10 the pins 80 seat into the centered slots 74 of the support
11 bracket 72 with the saddle portion between the side walls 72b
12 and enabling pivotal rotation of the saddle member 76 with
13 respect to the support bracket 72. Unlike the saddle member
14 32 of the upper support bracket 20, the pins 80 of the saddle
15 member 76 in the lower support bracket 72 need not be secured
16 in the centered slots 74. This is because the weight of the
17 specimen to be tested will secure the saddle member 76 without
18 separation from the support bracket 72.

19 A series of spacers 82 and overlying fixing plates 84 are
20 attached to that end wall 62 of the offset member 56 which is
21 not secured to the apertured end wall 52 of the lower support
22 fixture 12. The spacers 82 and fixing plates 84 create a
23 slide positioning mechanism securing the T-shaped base 70 of
24 the slider 66 to the offset member 56 through paired apertures
25 86, 88 of the spacers and fixing plates, respectively. These
26 apertures 86, 88 align with corresponding apertures 58 of the
27 spacer 56. This provides a finer spacing control for

1 adjustments less than the pitch distance between the matching
2 paired apertures 58 in the offset member 56 and those
3 apertures 46 in the lower support structure 12.

4 Due to the arrangement of spacers 82 and overlying fixing
5 plates 84, there are two different ways to adjust the distance
6 between saddles 76 mounted at opposite ends of the lower
7 support structure 12.

8 In a first distance adjustment, a coarse adjustment can
9 be made according to the selection of the bolt hole groups 26
10 used to secure the upper brackets 20 to the upper support
11 structure 11 and, likewise, the paired apertures 58 used to
12 secure the offset members 56 to the lower support structure
13 12.

14 In a second distance adjustment, a finer adjustment
15 mechanism is included in between the offset member 56 and the
16 slider 66. The series of spacers 82 and fixing plates 84
17 clamp the slider 66 to the offset member 56. This provides
18 spacing control that is less than the pitch distance between
19 the matching aperture patterns 58 in the offset member 56 and
20 the paired apertures 46 in the lower support structure 12.

21 During operation and as shown in FIG. 1, the lower
22 support structure 12 and the attached components as described
23 are positioned normal to the load column plane of the columns
24 104 of the flexure testing device and centered on the
25 stationary platen 102 (assumed to be the bottom platen) of the
26 flexure testing device. It is desired that equal lengths of
27 the end plates 50, 52 of the lower support structure 12

1 overhang the front and rear sides of the plane defined by the
2 load columns 104. Similarly, the upper support structure 11
3 and attached components are positioned normal to the load
4 column plane and centered on the moving platen 100 (assumed to
5 be the top platen) of the flexure testing device. The upper
6 and lower support structures 11, 12 are checked to be co-
7 planar to each other and the complete assembly is checked to
8 be normal to the load column plane.

9 The specimen is secured in the saddles 76 of the lower
10 support structure 12 and the testing device applies the load
11 by moving the upper support structure 11 downward such that
12 the upper saddles 32 are pushing down on the specimen under
13 test and the lower saddles 76 react the load upwards. The
14 saddles 32, 76 will rotate as the specimen deforms. This is
15 the follower-loading mode.

16 To utilize the non-follower-loading mode, locking pins
17 (not shown) are placed through corresponding holes in the side
18 walls 72b of the slider 66 and the pins 80 of the saddles 76.
19 The same is done for the apertures 30 in the side walls 24 of
20 the upper bracket 20 and the pins 36 of the saddles 32.

21 It should be understood that the subject specimen
22 supporting apparatus 10 is known to accommodate 96 inches long
23 specimens, however, there is no restriction for obtaining
24 specimen lengths beyond 96 inches. Both coarse and fine
25 adjustment mechanisms are included for setting the spans
26 between load and support points. A full range of load and
27 support point positions is thereby provided.

1 A rotational locking mechanism such as a pin is included
2 in the saddle design to enable the user to test in either
3 follower or non-follower loading modes. In a follower-loading
4 mode, the saddles rotate as the specimen deforms since the
5 resulting force vector remains in the same direction relative
6 to the localized region of the specimen to which it is applied
7 as the specimen deforms globally. In a non-follower loading
8 mode, the force vector remains in the same global direction at
9 all times and does not change directions as the specimen
10 deforms. The non-follower mode will transfer the load from
11 the saddle outer edge rather than along the saddle surface
12 are. Accordingly, to operate in a non-follower mode, locking
13 pins (not specifically shown) are inserted through
14 corresponding holes in the sides of the bottom slider and the
15 axles of the lower saddles, thereby securing them against
16 rotation. The same is done for the holes in the sides of the
17 top support and the axles of the upper saddles.

18 Other additional benefits are realized when coupling the
19 specimen supporting apparatus 10 to a flexure testing device.
20 These include, but are not limited to, testing the specimen in
21 a load-controlled mode such as a constant loading rate of 10
22 pounds per minute; and testing the specimen in a displacement-
23 controlled mode such as a constant displacement rate of 1.0
24 inch per minute. These types of tests are known in the art
25 and are included as examples of the uses of the present
26 invention.

1 There are several contemplated singular or combined
2 alternatives to the described subject disclosure, and these
3 are intended to be included within the scope of the invention,
4 although the invention is not limited to these suggested
5 alternatives.

6 In a first alternative, a T-shaped slotted block could be
7 used as an alternative to the slide positioning mechanism of
8 spacers 82 and fixing plates 84.

9 In a second alternative, the saddles 32 may be installed
10 within the upper bracket 20 and the saddle 76 may be installed
11 at the bottom sliders using bearings, needles, rollers, or the
12 like to reduce rotational friction forces when using the
13 follower loading mode.

14 Alternative structural shapes may be used for the various
15 components, such as box beam shapes for the upper and lower
16 support structures 11, 12 rather than I-beam shapes.

17 The slide positioning mechanism of spacers 82 and fixing
18 plates 84 shown in connection with the lower support structure
19 12 may also be implemented in connection with the upper
20 support structure 11.

21 In view of the above detailed description, it is
22 anticipated that the invention herein will have far reaching
23 applications other than those of flexure testing of elongated
24 materials.

25 This invention has been disclosed in terms of certain
26 embodiments. It will be apparent that many modifications can
27 be made to the disclosed apparatus without departing from the

1 invention. Therefore, it is the intent of the appended claims
2 to cover all such variations and modifications as come within
3 the true spirit and scope of this invention.